To such a statement I can only reply by placing before the reader the full list of the lizards occurring in the district now indicated by Prof. Heilprin as affording support to his views.

Lacertilia of the United States east of the Mississippi.

[The species with an asterisk prefixed are the only ones which reach 40° N. lat.]

GECKONIDÆ	1. *Sphærodactylus notatus.*
IGUANIDÆ	*2. *Sceloporus undulatus.*
	3. —— *floridanus.*
	4. *Anolis carolinensis.*
	5. —— *Cooperi.*
ANGUIDÆ	6. *Ophisaurus ventralis.*
TEIIDÆ	*7. *Cnemidophorus sexlineatus.*
AMPHISBÆNIDÆ	8. *Rhineura floridana.*
SCINCIDÆ	9. *Lygosoma laterale.*
	*10. *Eumeces quinquelineatus.*
	11. —— *anthracinus.*
	12. —— *onocrepis.*

XV.—*On some Points in the Anatomy of the* Temnopleuridæ. By Prof. P. MARTIN DUNCAN, M.B. (Lond.), F.R.S., &c.

[Plate XI.]

THERE is a great group of Echinoidean genera which is well characterized by a raised costulate or reticulate ornamentation of the plates, more or less grooved, furrowed and pitted sutures, small peristome, feeble branchial grooves, and small external branchiæ. The ambulacral plates are compound, the pairs in series of three, the tentacles homiopodous, the foramen of the pyramids closed above, and the teeth keeled. This group falls readily under that subfamily of the family Glyphostomata which my colleague Mr. Percy Sladen and myself called the Temnopleuridæ in our description of the Tertiary fossil Echinoidea of Kachh and Kattywar (Pal. Ind. ser. xiv. 1883, p. 54). But it is now necessary to advance the subfamily to the dignity of a family, for the group is large, requires subdivision into subfamilies, and is well separable from the other divisions of the Glyphostomata, such as the Triplechinidæ, A. Agass. It is the presence of a considerable number of fossil genera and a recent one, characterized by a large apical system with some of the radial plates entering the ring, a raised costulate ornamentation, without furrows and pits in relation to the sutures, having *Glyphocyphus*, Haime, as the type, that necessitates the subdivision. This group may become the Glyphocyphinæ, and the remainder of the genera, characterized by depressions, furrows, and pits of the sutures, dowelling between the coronal plates and a compact apical system, may enter the subfamily Temnopleurinæ. It is advisable to raise the position of the Glyphostomata into a suborder of Regulares.

According to Forbes's definition of *Temnechinus* and the result of the examination of the fossil forms from Sind, by my colleague and myself, there can be no valid reason for separating the genus from the Temnopleurinæ, and it might be urged that the genus has not more than a subgeneric value in relation to *Temnopleurus*. But when the admirable description of the recent *Temnechinus maculatus*, A. Agass. ('Revision of the Echini,' p. 286, pl. viii.), is studied, it is impossible not to agree with the author, and although there are some anomalies present the form must, from our present knowledge, enter *Temnechinus*. This being the case, it will be found that there are some decided distinctions between the species and any one of *Temnopleurus*, such as the large anal plate, the grooving around the tubercles, and the absence of true pits and deep grooves at the angles of the sutures, the grooving of the transverse sutures being slight. There is, however, a very great difficulty to be overcome before *Temnechinus* can come within the Temnopleurinæ, and it is the result of A. Agassiz's examination of the sides of the coronal plates. In the "Report on the 'Blake' Echini," Mus. Comp. Zool. Harvard, Memoirs, vol. x. no. 1, xxiv. pt. 1, 1883, p. 37. A. Agassiz wrote, "The specimens of different sizes which I have examined show no trace of pits nor of this system of dowelling at the junction of plates." The importance of this deficiency is great, and yet the peristome, the spines, and some of the pedicellariæ are the same as those of *Temnopleurus*. It appears then that the modern *Temnechinus* must be decidedly separated from *Temnopleurus*; but should the knob-and-socket arrangement of the union of the plates be discovered, *Temnechinus* will enter the Temnopleurinæ. It appears correct to associate the modern *Trigonocidaris*, A. Agass., with the Glyphocyphinæ.

The following observations upon some important structures of species of *Temnopleurus*, *Salmacis*, *Microcyphus*, &c. were made with a view of comparing the similar structures of *Temnechinus* and *Trigonocidaris* when an opportunity presented itself. It was also thought to be advisable to investigate the real value in a classificatory sense of the crenulation of primary tubercles and the presence or absence of grooves between the pores of a pair—two matters which have been made a great deal too much of in the classification of the fossil forms of Echinoidea.

The Sutures of the Plates.

The method of the union of the coronal plates of the Temnopleurinæ was discovered six years since, and the remarkable dowelling of the opposed edges of plates was described in species of *Temnopleurus*, *Salmacis*, and *Amblypneustes*, and subsequently in *Pleurechinus*, together with the nature of the sutural groovings and pits (Journ. Linn. Soc., Zool. vol. xvi. pp. 343 and 447).

I have now had the opportunity of examining better specimens of *Amblypneustes ovum*; and there is no doubt that the knob-and-socket structure upon the sides of plates is very well developed. The former specimens noticed were not in good condition as regards preservation, and it is a fact that if the fracture of any Temnopleurid is crumbling and very white in tint, changes have gone on which tend to destroy the appearance of dowelling, which, moreover, is not very visible in wet specimens.

Mespilia has the same junction-structure, and I find that *Holopneustes purpurescens*, Lütk., has knobs and sockets upon the opposed surfaces of the plates, with the exception of the component plates of the geometrical plates of the ambulacra. I do not find dowelling upon these plates in any genus, although it is recognized between the compound plates.

It would be expected that the thick tests of such a species as *Microcyphus zigzag*, Agass., would present some anomalous arrangement of plate-junction; but the knobs and sockets are in considerable numbers near the outer parts of the edges of the plates. On the plates on either side of the median ambulacral suture (Pl. XI. fig. 1) there are also some more or less straight rows of knobs or sockets, passing from within towards the outer part of the edge. This *Microcyphus* has a remarkable amount of union of the plates free from dowelling, and it appears that the ambulacro-interradial vertical sutures are inseparably united. In all other genera the test fractures very readily along this line, but in *Microcyphus zigzag* the test will break in the poriferous zone rather than separate at the suture.

There appears to be an amount of superficial growth of test which overrides the plates here and there in the ambulacra of *Microcyphus*, and this has to do with the abolition of the suture, as well as a remarkable blotting-out of plates, which will be mentioned further on.

The Sutures as seen in Decalcified Specimens of Temnopleurus toreumaticus.

After decalcifying in dilute hydrochloric acid in spirits of wine, washing, staining with hæmatoxylon, placing in absolute alcohol, clearing and mounting, the sutures between the interradial plates become beautifully distinct, on account of the presence of a lamina or ribbon-shaped process of reticular connective tissue, which dips down between the contiguous edges of the plates. It appears to be that part of the connective tissue of a plate or plates in which the knobs and sockets, made up of very reticular spicules of carbonate of lime, are deposited as the test grows. In some parts, especially in the apical region, the suture between two plates is recognized by a cross-layering close to the divisional line.

The Structure of the Ambulacral Plates.

The ambulacral plates of all the Temnopleurinæ are compound, and the pairs of pores are in triplets, which vary in their obliquity, vertical closeness, and horizontal distance. The least complication is seen in the genera *Temnopleurus* and *Salmacis*, and the greatest is observed in *Microcyphus* and *Holopneustes*. It is evident that two factors produce complexity, and they are diminution of the vertical dimensions of the compound plates and thickening of the test during growth.

Simple as the ambulacral plates of *Temnopleurus* and *Salmacis* are, they afford a good introduction to the study of the more complicated forms.

Temnopleurus and *Salmacis*. (Pl. XI. figs. 2, 3, 4.)

In all the species of these genera the ambulacral plates are in compound geometrical forms, which are low and broad in *Salmacis* and taller and narrower in *Temnopleurus*. In all species the compound plates are made up of three components; the upper or aboral component (*c*) is a long low primary, and the middle one (*b*) is a low short demi-plate with a very curved inner or adoral suture which reaches the adoral suture of the primary just noticed, as it passes upwards. The lower or adoral component plate (a) is a large primary, and it occupies most of the compound plate. This is a very usual arrangement, and is similar to that of *Echinus* and its allies; but the inner suture of the demi-plate differs in the nature of its curve, and it is not simply oblique, as in *Echinus* proper.

The triple pairs of pores are more in arcs in *Salmacis* (fig. 4) than in *Temnopleurus* (figs. 2, 3), and in both genera the pores of pairs are much wider apart on the inside of the test than they are in the peripodia (compare figs. 2 and 3).

Mespilia. (Pl. XI. fig. 5.)

The same arrangement of plates and pairs of pores as is seen in *Temnopleurus* and *Salmacis* occurs, slightly modified, in *Mespilia globulus.* The compound plates of this species are decidedly low and broad, and more so than in the genera just alluded to. The pairs of pores are in triplets, the pairs being close vertically. The middle pair of pores of the triplet (b) is close to the ambulacro-interradial suture in a rather broad, low, demi-plate, whilst the aboral pair (c) is nearly vertical to the adoral pair (a). Both of these pairs are in primary plates, the adoral being in the largest. As in the other genera the pores of a peripodium are much closer than their continuations within the test.

Microcyphus. (Pl. XI. figs. 1, 6–12.)

There are some very remarkable and, in my experience, unique structural characters about the ambulacra of *Microcyphus zigzag*, Agass., which appear to be due to the growth in thickness, externally and internally, of the plates and to the very oblique paths of the canals of the pores. Blocking out of the ends of component plates occurs, and some plates which are perfectly visible on the inside of the test are not seen on the outside, and they have been hidden by the continuous superficial deposit of test material. Moreover, parts of the component plates of compound ones are sometimes separated from their sutures in a very unusual manner (fig. 1).

On looking at the ambitus of a specimen (fig. 6) the low broad ambulacral plates, which are broader superficially than within, are noticed to have an adoral pair of pores (a) nearer the median line of the ambulacrum than the other pairs, which are oblique and close to the ambulacro-interradial suture; a number of plain tubercles and miliaries are upon the plate, some small ones being amongst the pairs of pores, which are large and in peripodia and separated by a narrow process. On looking at the inside of the corresponding part of the test (fig. 7) it is impossible to recognize the external arrangement. The pairs of pores are in a very slightly curved vertical series, and the adoral pair of perforations (a) is not much or at all out of the direction of the other two pairs. But the obliquity of the canals of the adoral pair is great (fig. 8), and in all cases there is more plate-structure between the pairs of pores and the ambulacro-interradial suture than is visible on the outside. The pores are quite 1 millim. to 1·5 millim. apart, on the inside of the test.

The test is very thick, and the ambulacro-interradial sutures are quite obliterated, and fracture will most certainly not occur along that line. The sutures between the compound plates are slightly depressed or broadly grooved on the free outer surface of the test, and the pits are exceedingly shallow.

Taking a plate at the ambitus which is normal, and they are rare, and applying benzule, a line of suture is seen to pass below the upper peripodium of the triplet with a downward curve across the plate, to reach the median sutural edge close to the aboral median angle. This suture marks the adoral boundary of the upper component of the plate, and it is a primary (fig. 6, c).

A line passes adorally to the middle peripodium (b) of the three, and curves with a slant upwards and joins the other suture at no great distance towards the median line. This line is the adoral suture of the median plate of the compound, and it is a small demi-plate (fig. 6, b).

The line just mentioned nearly touches the aboral edge of the lowest or adoral peripodium (a) of the innermost pair of pores, and they are placed in a primary plate, which carries the ornamentation of the greater part of the combination (fig. 6, a).

An inner view of this plate (fig. 7) shows a simple curved series of pores, the width apart of the pores of a pair being much greater than in a peripodium. The path of the sutures is very distinct and is very like that of *Salmacis*. The obliquity of one of the canals of the adoral pair is shown in fig. 8.

Near the apical system the compound ambulacral plates are narrower than at the ambitus, but are made much upon the same plan; but a little lower down very remarkable differences are seen on the inside of the test.

A compound plate will be seen not far from the apex, within, and its component plates are all primaries (fig. 9, x), and if their middle sutures were more curved, the arrangement would be Diadematoid; but the adoral suture of the upper and the aboral suture of the lower primary are nearly transverse. Nearer the ambitus are some arrangements of plates unlike any hitherto noticed. There is an upper compound ambulacral plate (fig. 10) and the aboral component is a long low primary (*c*) with its adoral suture dipping towards the next plate in adoral succession. This plate (*b*) is a small triangular one, and its adoral suture *does not reach the adoral pore of the pair belonging normally to the plate.* Under the use of evaporating benzule I cannot detect *any suture coming from the adoral pore.* Consequently the adoral component (*a*) of the plate under consideration is a large primary, and includes the adoral pore of the pair properly belonging to the demi-plate above. In the compound plate next below, the upper component plate (*c*) is the usual primary, and the next (*b*) is a demi-plate with its suture *passing from the adoral pore of its pair vertically* to the corresponding or adoral pore of the pair of the primary above. The dotted line is in the path of a thickening which recalls the position of the suture in fig. 9.

In the next plate (fig. 11) the suture of the adoral pore of the middle plate (*b*) is plainly turned obliquely upwards and *outwards* to reach the small demi-plate, and the first stage of the exclusion of a pore from its plate is exemplified. Fig. 11 is of two compound triple plates, and in the upper one the aboral member is a low primary (*c*); the next plate (*b*), which should have been a perfect demi-plate, is one which only contains the aboral pore of its pair, and is excluded from the ambulacro-interradial suture. The adoral pore of the pair (*b*) has its suture just touching the union of the adoral suture of the single pore-bearing plate with the adoral suture of the upper primary (*c*).

The lowest plate (*a*) is a large irregular primary. The same condition of things is seen in the next or actinal compound plate (the lowest of fig. 11), but the aborted plate (*b*), with only one pore, is not excluded from the ambulacro-interradial suture. Below the ambitus of the test the variety in the distribution of the sutures, as seen from within under benzule, is as extraordinary as abactinally, for (fig. 12) in a well-marked example the upper (*c*) component is a low primary with a dip down of its adoral suture towards the space between the pores of the middle (*b*) component plate, and the adoral pore has got above and out of the touch of the adoral suture. The middle pair of pores (*b*) has its aboral pore in a demi-plate; but the adoral pore *is on the line of the adoral suture of the upper* *primary plate* (*c*). The lower component is a normal primary (*a*).

If the ambulacral plates are separated along the ambulacral median suture the usual knobs and sockets are seen upon the opposite edges of the plates, and amongst them dark lines are seen under benzule (fig. 1). The knobs and sockets in the figure are in lines and groups, and most are near the outer part of the test; the lines are almost straight and some reach from one surface to the other, and all are the joined sutures of primary components of compound plates.

Some lines, however, have a slant, and whilst most are simple, others have a curved offshoot which starts below the outer surface and, after curving, becomes straight. As the space included between two lines of sutures is a plate or part of one, so the surface between the bend and the straight suture is a part of a plate. That this is the case is easily noticed in such plates as fig. 9* (*a*), for the line of the adoral suture of the upper primary (*c*) can be traced to the median edge of the plate and partly upwards, but not to the surface of the test; it is represented in fig. 9 at *x*. In every instance of this bending of a sutural line as it passes from within outwards in the test there are proofs of the outward addition of material having buried the suture and its plate, so that the outer markings of such a plate would not tally with the inner, and these last are relics of the early state of growth of the test.

Amblypneustes.

The ambulacral plates of *Amblypneustes* (fig. 13) are low, broad, and thin, and the pairs of pores are in large peripodia; the adoral pair of a triplet is not placed relatively so far inwards as in *Microcyphus*; but the appearance on the inside of the test is very different. In *Amblypneustes* the middle pair of a triplet is nearest the ambulacro-interradial suture, and the aboral pair is placed obliquely above and inwards to the middle pair; and this obliquity is continued to the adoral pair of pores of the plate next in vertical succession. Hence there is the common appearance presented of sets of oblique pairs in threes, and this is shown to perfection inside the test, and the appearance is intensified by the obliquity of succeeding sets of three having their inner pores along the same oblique line as the outer pores of triple pairs placed above and below.

A primary plate, which is the aboral constituent of *Microcyphus* (*c*, fig. 6), does not exist, however, in *Amblypneustes*, for the aboral component (fig. 13, *c*) is a low broad demi-plate; the middle plate (*b*) is a low narrow demi-plate, and the adoral pair of pores is in a large primary plate (*a*).

Holopneustes.

The nature of the ambulacral plates of *Holopneustes purpurescens*, Lütk. sp., is much easier to comprehend than that of the other and broad poriferous zoned species, *H. porosissimus*, Agass. But the same method of examination must be employed as in other polypores, and when it has been mastered in the first-named species the difficulty vanishes with regard to the apparent confusion of the plates in the other form. The rule must be followed which enables the adoral pair of pores or their peripodium to be distinguished; and it must be remembered that in the great majority of instances the pair is nearer the ambulacral median line than the other pairs of a compound plate.

In *Holopneustes purpurescens* (figs. 14, 15, 16) the ambulacral plates are low and broad, and usually there are double plates near the ambitus (fig. 14) consisting of two vertical sets of triplets combined in a geometrical plate; elsewhere the plates are single, or there may be an alternation of single and double plates. The test is rather thin and the poriferous zone is rather broad, the peripodia being triserial in arrangement. The pairs are close vertically and rather distant horizontally. One vertical row of pairs is very regular and is internal, that is nearest the interporiferous area, and each pair is in the adoral plate (*a*) of a compound plate. This adoral plate is a primary, and forms most of the interporiferous part of the geometrical plate; it extends to the median suture; but it may be excluded from that part of the poriferous zone which is close to the ambulacro-interradial suture (figs. 14–16), or, as is the case near the apical system, it forms all the adoral part of the compound plate and reaches the ambulacro-interradial suture (fig. 15, *a*).

The outer vertical series of pairs of pores is also a very regular one and consists entirely of those belonging to the middle components (*b*, figs. 14 and 16) of compound plates, the component plate being a narrow demi-plate. Near the apical system the little demi-plate (*b*, fig. 15) is separated from the adoral suture of its geometrical compound by a low part of the primary just noticed; but usually there is no such interval, and the expansion of the demi-plate has caused the *exclusion of the portion of the primary immediately adoral to it* (figs. 14–16). It is this blotting-out of part of a plate which causes the outer and inner pairs of pores of a triplet to be so nearly on the same horizontal line.

The middle series of pairs (*c*) confused or not in vertical succession relates invariably to the upper or aboral plate of a compound geometrical plate; and this should not be forgotten in investigating the distribution of plates in the very complicated poriferous zones of the other species of the genus. Each pair of the middle series is in a low but broad demi-plate, and is placed remotely from the ambulacro-interradial suture (fig. 14, *c*).

Every compound plate consists therefore of a low triple set of pairs. It should be noticed that the pores are very oblique in a peripodium.

On examining the test from within, a different arrangement of the pores is observed, but the great dissimilarity noticed in *Microcyphus* does not occur. Nevertheless the pores of a pair are much further apart than on the free surface, and the great horizontal distance of the pairs is not recognized.

Seen on the inside of the test (figs. 15, 16) the pairs of pores are in zigzag, but the adoral pair can be recognized by a certain vertical arrangement and by the inner or adoral pore of the pair being large and at the end of a short groove; the other or aboral pore is small, circular, and is placed obliquely upwards and outwards. Fig. 15 is a view, slightly diagrammatic, of two compound plates near the apex, seen on the inside of the test during the action of benzule. The adoral pairs of pores are readily distinguished, because the adoral pore is upon the lower horizontal suture of the compound plate. The contact of the adoral primary plate is seen with the ambulacro-interradial suture. In fig. 16 the exclusion of the corresponding plate *a* is seen, and in all plates a singular curvature of the lower horizontal suture occurs, and it is curved up towards the upper pore of the pair before passing outwards to the ambulacro-interradial suture. This curving is very anomalous, and is especially distinct when the primary is excluded.

The outer and more or less vertical row of pairs of pores, with one of the pores close to the ambulacro-interradial suture, is the middle pair of the compound, and is in a small demi-plate; its pores are much more horizontal when seen from within than in the peripodium (figs. 15, 16, *b*). The highest pair of pores of a plate is further from the ambulacro-interradial suture than the pair just described, and its pores are variably placed as regards verticality, and they often overlap the outer pore of the adoral pair and the inner pore of the pair in the demi-plate; the inner pore of this aboral pair is usually nearly vertical to the outer pore of the adoral pair.

The pair corresponds to one of the middle vertical series (*c*) seen on the outside of the test, and is in a low broad demi-plate.

It is not difficult to make out the sutures of the compound plates with benzule near to the apical system; but the crowding of the plates lower down and the absorption of a part of the adoral primary, together with the horizontal curvatures of some of the sutures, place considerable difficulties in the way.

The adoral suture of a compound plate (fig. 15, *a*) is horizontal near the apical system, and usually but not invariably so when the primary is not partly excluded (fig. 1). The adoral or large pore of the primary plate, *a*, is of course traversed by the more or less horizontal adoral suture of the geometrical plate; but the small circular aboral pore of the pair is not remote from the suture, as is usually the case in Echinoidea, for the suture bends up to it more or less. The direction of the suture from the aboral pore outwards is either straight or in a slight curved convexity directed upwards. In this last instance the suture is in contact with the adoral pore of the narrow demi-plate *b*, fig. 16. It is anomalous for one line of suture to cross the adoral canals of a lower and upper plate; but it is well exemplified in the case of this *Holopneustes*.

When the primary is not excluded (fig. 15, *a*) the middle demi-plate of the compound has an adoral suture of its own, and at or close to the adoral pore of the pair it turns upwards with a curved concavity towards the ambulacral median line, to reach the adoral suture of the aboral or upper component of the compound plate. The aboral or outer pore of the pair is not remote from the horizontal suture (fig. 15, *b*), and is often upon it.

The aboral plate of the compound seen from within (figs. 15, 16, *c*) is a low demi-plate which is longer than the middle demi-plate, and when the primary (*a*) is not excluded its adoral suture is horizontal and turns up with a curve to reach the upper edge of the compound plate just between the pores of the adoral pair of the next geometrical plate in vertical succession. But when the primary is excluded the adoral suture of this upper component is curved convexly downwards, and it has its curvature continued so as to join the horizontal suture between the compound plate and its fellow above, a little external to the adoral pore of the pair belonging to the adoral primary component of the plate above. The appearance given under benzule is of a number of low ellipses placed vertically, and they are formed by the adoral sutures of the upper plates and the aboral sutures of the lower plates in succession (fig. 16).

The Pits.

The pits at the sutural angles and elsewhere are described in the communication already alluded to (Journ. Linn. Soc., Zool. vol. xvi.).

The distinctness of the pits in *Amblypneustes* and their slight depth in *Mespilia*, *Microcyphus*, and *Holopneustes* is evident, and A. Agassiz has pointed them out along the lines of sutures as well as at the angles in *Pleurechinus* and in a species of *Amblypneustes.* But the pitting is in excess in *Temnopleurus* and *Salmacis,* and is less in the genera just mentioned. The pits near the peristome in *Temnopleurus toreumaticus* have a large and rather depressed spheroidal sphæridium at their entrance *, and many others have a pedicellaria close by. It does not appear that there are any special functions relating to the pits, and the same thing may be said in respect of the deepening, grooving, widening, and depressing of the outer surfaces of the plates close to the sutural lines; but it is clear that these modifications of the test enable a larger amount of outer test surface to come in contact with water.

The Articulation and Muscles of the primary Spines.

The spines are for the most part slightly compressed, and some are very much so; they have a well-developed milled ring, which is broader than the rest, and which has its milling continuous with the longitudinal fluting of the spine. The spine diminishes in breadth below the milled ring very rapidly, and the hollow cotyloid cavity has a blunt free edge more or less notched.

The spines are cellular within, with a double series of radiating processes and a very narrow circular central space (fig. 28).

The primary tubercles have a well-formed scrobicule, which slants down from the boss and is often slightly raised externally, so as to present a prominent circular border; it is plain and smooth, except close to the boss, which has a decided crenulation upon it close to the neck of the imperforate and projecting globose mamelon. The cotyloid cavity of the spine fits upon the mamelon, and the notched free edge comes in contact with the crenulation of the boss, so that the mamelon is well hidden. As Valentin described in 1841, the joint of the spine and tubercle has three layers—the outer an epithelial, pigmented and ciliated, thin layer, a middle thin and more or less fasciculate layer of muscular fibres, and an inner articular capsule.

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* Lovén, Études, pl. x. fig. 38.

Valentin's researches were made upon species of *Echinus* with smooth bosses, and as those of *Temnopleurus* are crenulate their examination is not devoid of interest, especially as the question of the classificatory value of crenulation is constantly arising.

In *Temnopleurus* the inner structure surrounding the joint is the articular capsule, which is a white, soft, mass of imperfectly differentiated matter, with granules, connective tissue, and extremely indistinct fibres. The microscopic appearances are very negative. The white matter adheres to the lower part of the spine, below the milled ring, and to the edge of the cotyloid cavity ; it is firmly adherent to the crenulation on the top of the boss of the tubercle. A quantity of the white enclosing substance is spread over the surface of the boss and scrobicule like a flap, but there is some definite connexion between the hard and soft parts. This soft capsular structure is very weak, however, and if the outer muscular layer is ruptured, soon gives way to a slight pull or to unusual depression of the top of the spine. The fracture occurs at the point where the free edge of the lower end of the cotyloid cavity is movable upon the crenulation of the boss. Dislocation of the spine then occurs.

The muscular layer is considerable in height, although very thin, and it reaches from its origin around the edge of the scrobicule of a tubercle, upwards to the inferior edge of the milled ring of the spine ; it covers the articular capsule and neither receives fibres from the boss nor from its crenulation. The muscular fibres arise from the connective tissue of the outer edge of the scrobicule, and they are very delicate, separate under the microscope, and exceedingly simple. There are no differentiated structures in them, and the distribution in bundles is not striking, and indeed it does not usually exist. The nervous supply is considerable, beneath the muscular fibres, and the very minute nervous fibres have ganglion-shaped parts upon them*. The delicate layer of cells which is situated upon the muscular layer may deceive a young microscopist into crediting that there are cross light and dark marks in the muscular fibres; but careful illumination and the use of a lens capable of good definition expose the error.

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* The minute anatomy of most of the parts of some species of Echinometradæ and Echini has been of late worked out with great success, and published by Otto Hamann ("Beiträge zur Histologie der Echinodermen," Jenaische Zeitschrift, Bd. xxi., Neue Folge, Bd. xi. p. 87, 1887).

Diadema setosum has the primary tubercles with crenulated bosses and perforated mamelons, and the part of the spine between the lower end or edge of the cotyloid cavity and the milled ring is very long. I find that the muscular investment of the joint greatly resembles that of *Temnopleurus*, that it arises from the outer edge of the scrobicule of the primary tubercle, and is inserted at the lower edge of the milled ring, and possibly here and there upon the outside of the spine below the milled ring and the capsule of the joint. This capsule covers the ends of the spine and the top of the boss and covers the crenulation and extends as a flat layer beyond it.

No muscular fibres penetrate this capsule, and none arise from the crenulation. It is interesting to note that in the same specimen of *Diadema* some of the bosses are perfectly crenulated, others are half crenulated, and not a few may be destitute of the structure. This is not uncommon in other forms.

It would therefore appear that crenulation and perforation of the tubercles is not of sufficient physiological importance to distinguish genera, although it may be useful in grouping species.

The Branchiæ. (Pl. XI. figs. 17–21.)

The branchiæ of *Temnopleurus* and *Salmacis* are small and narrow, although moderately long. They are situated upon the peristomial membrane, close to the small so-called "incisions" or rather grooves, one of which is placed close to each ambulacro-interradial suture at the peristomial margin. The branchiæ protrude and reach up over the edge of the grooves and may be 2 millim. in vertical measurement. In *Temnopleurus* (fig. 17) the narrow branchiæ are in finger-shaped processes, from six to twelve or more in number; they arise from a hollow stem and rarely bifurcate, but some are in tufts which come from the same source. All are tumid, rounded at the free end, and hollow. Decalcified specimens show that there is an outer thick layer of columnar epithelium (fig. 18), the cells containing granules which are most numerous at their bases (fig. 19); but it appears that there may be groups of cells so crowded with pigment corpuscules that a definite pattern is presented on the outside of the finger-shaped body, consisting of longitudinal, irregular, narrow, wavy lines. This ornamentation is also seen upon the main stem or water-tube.

The hollow of a process is lined with a smaller and less columnar endothelium, with granules, and it appears to line a somewhat irregular basement membrane (fig. 18). Between the outer and inner series of cells is a somewhat wide space readily transmitting light, and having no definite structures in it, and in specimens which have not been decalcified calcareous spicules are found there in some abundance.

In *Salmacis* (fig. 20) the branchiæ are larger and stouter than in *Temnopleurus*; they are, however, narrow and spring from a larger and higher stem. The processes are more in tufts, and are shorter and more numerous than in *Temnopleurus*. These branchiæ pass up over the margin of the peristome at the branchial grooves and reach along the flanks of the ambulacra for a line or two. The principal structure to be noticed is that which is visible before applying acids. The calcareous spicula are separate, moderately numerous, and variable in size and shape. "C"-shaped spicula are seen, but are not common, and the others are bifurcate or pinnate; and on the water-tube there are numerous fenestrated elliptical or irregularly shaped plates.

The Ampullæ. (Pl. XI. figs. 21, 22.)

Decalcified portions of the ambulacra of *Temnopleurus toreumaticus* stained with hæmatoxylon were used. The ampullæ are small and bolster-shaped near the apical disk and become gradually larger and closer in vertical succession towards the ambitus, where they are large, long, from side to side, and tallest near the median ambulacral water-tube (fig. 21). Their actinal edge is tumid and more or less gibbous, a swelling being noticed close to the water-tube and a contraction midway between the two ends, and there is more or less of a narrowing quite at the part which corresponds to the poriferous zone. The abactinal edge is less irregular and runs up to a blunt point at the poriferous zone end. They are broader than high and tumid. The opening into the water tube is seen by transmitted light very plainly, but the holes for the tentacular canals are indistinct. They are placed in the interradial side half of the ampullæ and are recognized as a dull elliptical space, which appears to be more or less occupied by fibres of the inner part of the base of a tentacle which have become compressed over the openings of the pores externally.

The structure of the walls of the ampullæ is very interesting, and they are not simple bags with a contractile coat. The bag is composed of very delicate, close, exceedingly narrow circular fibres, which in the main are vertical, although they depart from that direction in the gibbous parts. The accessory structures are irregular transverse rows of small elongate pigmented spots, which, in sections or oblique views of the ampullæ, are seen to be the outer terminations of fibres resembling the usual unstriped fibres of small spines, which pass inwards to varying depths in the hollow of the ampullæ, and are attached to reticulations of connective tissue (fig. 22). These fibres exist in *Psammechinus* and are very suggestive of less definite structures, which may be noticed in the abactinal branchial tentacles of *Cœlopleurus*. These spots give a very marked aspect to the outside of the ampullæ, and their inner prolongations probably prevent too sudden expansion of the calibre of the ampulla, and may also assist in the contraction required for the infilling of the tentacle. A very delicate epithelium and endothelium* occur.

It is interesting to notice the great size of the ampullæ in relation to the dimensions of the bases of their tentacles at a slight distance from the apical system, and to observe that the bags reach quite across the whole breadth of the ambulacral plates.

It appears from the examination of the bases of the tentacles, that the so-called geminous or reverse condition of the pores of the pairs is not of the least physiological importance, and whether there is a groove externally on the test between the pores or whether there is a granule or nodule between them is of no significance in a natural system of classification.

In the specimens which gave the above results the ampullæ were tense and tumid, but in some others, in which they were seen to be empty and flaccid, there was some departure from the exact shape, and moreover the internal fibrous arrangement was not visible. This was doubtless due to the considerable time during which the test had been in impure alcohol. The two openings for the tentacular canals were, however, very visible, and there was no vestige of any valvular structure. But a fortunate section of the tentacle of one of the ampullæ showed that the inner membrane is continuous through the pores with that of the ampulla.

The Tentacles. (Pl. XI. figs. 26, 27.)

These well-developed structures of *Temnopleurus* are similar throughout the ambulacra, and the genus is therefore homœopodous. The tentacles are moderately long and stout in alcoholic specimens, and their bases are broad and encircle the not very strongly marked peripodia; the stem soon becomes cylindrical and very slightly tapering, and it diminishes somewhat suddenly in diameter close to the large suctorial or cup end. The hollow of the tentacle is well seen, and it is the outcome of the junction of two short canals which come through the two pores of each pair. The separation between these canals is very slight in the base of the tentacle.

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* See also Hamann, *op. cit.* pl. xiv. fig. 3.

The plan adopted was to decalcify some specimens and to colour and mount in balsam, and to mount others without decalcifying them.

In the decalcified specimens the tumid edges of the sucker end are more or less faintly lobed, and there is evidently some circular arrangement of fibres there. This would tighten the grasp of the cup-shaped end, and would act upon the quadripartite calcareous circlets which will be mentioned further on. A thick epithelium and much connective tissue below it form the bulk of the cup, and are continuous with the similar structures of the outside of the body of the tentacle. On the body this structure is very delicate, and the epithelium is rather more columnar than flat, it contains granules and has cilia. In some tentacles there is much thickening of the epithelial part near the neck of the cup, and much transverse folding of it and the subjacent structures, but elsewhere the cells may be excessively thin and transparent.

Four sets of muscular fibres are visible in a tentacle: first, the circular fibres of the cup; secondly, the concentric and radiating fibres of the top of the tentacular cavity and base of the cup (see Lovén, 'Pourtalesia,' p. 49, pl. xi. figs. 112–115); thirdly, the outer layers of circular fibres; and fourthly, the innermost muscular layer composed of longitudinal fibres. The circular fibres are most developed near the cup and in what may be called the neck of the tentacle; but elsewhere their presence varies most remarkably. In some tentacles a delicate close layer can be distinguished composed of exceedingly narrow, close, circular fibrils of great slenderness; they appear to be nucleated here and there and separate; striation does not occur. In other examples the circular fibres are very scarce and wide apart; in some they do not exist.

The longitudinal fibres reach from the base at the peripodium, where they are stout and very visible, up the shaft, where they become excessively attenuate and slightly distant, to the base of the cup below the calcareous structure. They are often slightly wavy, nucleated, and unstriated (see also Hamann, *op. cit.* pl. xiv. fig. 7).

The circular fibres are placed over a delicate membranous tissue which may sometimes be seen projecting beyond the cut end of a tentacle, and this is clearly epitheliate and very minutely granular. Probably it is ciliated, but no trace of cilia came under observation. The longitudinal fibres are usually somewhat coloured naturally at the peripodia, and arise by broadish bases, and soon attenuate; they are apparently separate and not in fascicles. As is the case around the origin of the muscles of the spines, there is a very fine lax entanglement of threads much less in diameter than the thinnest muscular fibre around the peripodium, and it is apparently nervous in character. The nerves have small simple ganglionic swellings, and conform to Lovén's well-known description, except that I have not seen multipolar cells uniting.

The tentacles which are between the ambitus and apical system are larger than those situated actinally, and their calibre and middle space are greater, the muscular walls are more attenuate, and the cup end is more tumid and smaller. These tentacles have a more baggy appearance than the others, and when decalcified the muscular layers are very distinct, especially the transverse or circular series, which is so feebly developed in the actinal set. In fact these tentacles resemble in a minor degree the similarly placed structures of *Salmacis*.

The muscular fibres which close in the free end of the tentacle pass inwards from the stout continuous calcareous spicules which form the foundation of the circlet of calcareous reticulation of the cup; this more or less quadrangular continuous structure Lovén has called the foot-ring or "psellion" (Lovén, *op. cit.* pp. 49, 50). The muscular fibres unite at the centre of the neck of the tentacle and form the floor of the sucker or adhering apparatus.

The psellion is so arranged that the spoke-like spicules of the four parts of the calcareous circlet spring generally from the middle of one of the four main spicules of it, and the junction of one main spicule with another marks the line of separation of the parts of the circlet (figs. 26, 27). Immediately below the psellion are two very slender spicules of the same length, and they are connected by vertical and distant short spicules. Sometimes a ragged areolar lamina extends slightly over the edge of the muscular circle.

The calcareous circlet of the cup, springing as it were from the psellion, and nearly reaching the circumference of the free end of the cup, is very decidedly divided into four parts, and each part is composed of a reticulation which has five or six spoke-like processes which traverse the lamina of the circlet and are free at its circumference, some ends being simple points, others double or cellular. Between the spokes are cross pieces, and hence the reticulate and fenestrated appearance. At the sides of each lamina, that is at the four divisions of the circlet, the radiating spicular elements are stouter and not on the same plane; the consequence is that the space between the contiguous side spicules is not very distinct and sometimes it is clearly vacant, or there may be a slight reticulation in parts. Lovén considered that probably there are muscular fibres between the side spicules of the four parts of the circlet in *Toxopneustes*, and although they are not visible in the specimens before me, the possibility of their existence in fresh specimens is very considerable; certainly these separate parts of the circlet would be approximated by the contraction of the circular fibres of the soft parts of the cup.

Very few "C"-shaped spicules are present in the tentacles of *Temnopleurus*, and I have only seen one instance of an acerate spicule.

The circlet of the cup of the larger and wider abactinal tentacles is smaller than that of the actinal and is less elaborately ornamented.

Salmacis differs decidedly in the construction of its tentacles from *Temnopleurus*. The abactinal tentacles are large, long, baggy, and have small terminal cups; the actinal have stout walls, are shorter, thicker, have a narrow calibre, and the cup is large, fleshy, and the circlets are well developed and very large.

A circlet of an actinal tentacle has six or even seven divisions, and each is as distinct as it is in *Temnopleurus*; the spoke-like processes are much more numerous and pointed, and on the same circular line. The psellion is well developed, and its accessory processes also. The central muscular structure is larger than in *Temnopleurus*, and there are many "C"-shaped spicules all about the cup and the upper part of the tentacle. The muscular structures are as in *Temnopleurus*. Now the cup of the abactinal tentacles supports a very small circlet, and its divisions are fewer in number than they are in the actinal tentacles, but the "C"-shaped spicules are in greater profusion, and the muscular layers are composed of better developed circular fibres and very distinct longitudinal ones.

The Pedicellariæ. (Pl. XI. figs. 23, 24, 25.)

These beautiful organs occur in vast numbers in *Temnopleurus toreumaticus*, but it must be understood that dry tests do not furnish a moderate proportion of those which may be seen in specimens preserved in alcohol immediately after capture. The reason is that most of all kinds of the pedicellariæ have soft and long or short flexible limp necks, others are placed upon solid stalks. The majority of the soft-necked pedicellariæ fall off in drying and are lost. This can be easily proved by examining dry specimens and collecting their pedicellariæ, and then comparing the results with the appearances presented by decalcified and coloured parts of the test preserved in balsam. Every pedicellaria of an ambulacrum and of a radial plate can then be preserved, and it is remarkable how they crowd some spots and how long the necks are in relation to tentacles. The very fleshy look of the heads of pedicellariæ is striking, and so are the muscular developments of many.

The removal of some of the larger spines is necessary before parts of the test are decalcified, but care must be taken to notice the numerous pedicellariæ which are around the scrobicular circles. Some of the pedicellariæ are very large, and on the other hand the majority are exceedingly small. Sladen's gland within the body is visible and moderately developed in one group; but the glandular structure common on the stems of the pedicellariæ of some other genera are absent.

There is no difficulty in distinguishing four kinds of pedicellariæ in *Temnopleurus*.

1. Large tridactyle forms with a broad base to the body and very long prongs which are moderately broad, arched, becoming slightly narrower and not very sharp-pointed at the free end, being well fenestrated, and having a wide space between the lower parts of the prongs of contiguous valves. The sides of the prongs are slightly dentate, but there are no terminal teeth.

These largest forms are rare and are seen near the basal plates upon the interradia, and here and there close to an ambulacrum. One or two are upon short stalks, others are upon long and slender ones placed upon small secondary tubercles or upon miliaries, and having muscles at the joint. The most interesting series has a long, soft, transparent neck placed upon a stalk and consisting of a glairy-looking structure, in which a few longitudinally placed muscular fibres, some indefinite granular tissue, and pigment-spots occur. These necks are long or short and limp, and they are found curled around neighbouring structures after death; they are continuous with the outer tissue of the stalk, and are excessively fragile.

2. Common tridactyle pedicellariæ with smaller valves than the above, the base wide and suddenly diminishing, the prongs narrow, slender, very wide apart, long, and ended by a sharp curved point, below which are two others, one on each side (fig. 23). The whole is fenestrated. The largest of these forms are seen actinally, as well as close to the apical system, and around the bases of the large spines. The ambulacro-interradial sutural region is a common spot.

Smaller tridactyles with slightly stouter prongs are very common, and are found very generally distributed.

Both of these forms of tridactyles often have long, soft necks and are placed upon long or short spinules; some are without necks, and are either sessile or with stalks.

3. The globifera (fig. 24)* are very common, and there are a few very large ones near the apical system and a host of smaller forms very generally placed, and notably along the ambulacra and the median area of the interradia. The large and small have the same structure. The base is broad and tumid, gracefully merging into the broad, moderately long, broad, boldly curved, slightly angularly-ending prongs. The sides of the valves are distantly serrate, and a stout calcareous ridge runs along the median line, and has lateral offshoots, and in the hollows between are minute openings. This is a very marked character. These pedicellariæ are, as the others, either placed upon soft necks or upon stalks of varying length, some 1 millim.

4. The triphylta or ophiocephalous pedicellariæ (fig. 25) are in vast numbers, and are at once recognized by their very small size, their blunt free ends, tumid subcylindrical shape slightly longer than broad, and their very minute perforations. They have very blunt terminations to their valves, no teeth, and when looked at from above a trefoil appearance is seen. They occur in vast numbers in the actinal region of the ambulacra and around all primary and secondary spines, around many tentacles, and upon the radial plates. There are none upon the peristomial membrane or upon buccal plates. Most are

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* The globifera of authors, not especially of Otto Hamann, who would term them gemmiformes. The globifera of that excellent microscopist are large tumid tripartite globose-looking pedicellariæ without calcareous heads, and with a very strong muscular layer. They secrete, and are, according to Hamann, very generally found on certain species of Echinoidea. I have evidence of their occurrence in *Temnopleurus*, near the apical disk, although I was not fortunate enough to discover them in *Sphærechinus*.

placed upon soft necks, and these are of different lengths, and so are the stems on which the necks are situated.

In *Salmacis* the distribution of pedicellariæ is not the same as in *Temnopleurus*.

The peristomial membrane of *Salmacis bicolor* has ten buccal plates, which not only carry tentacles but a crowd of rather long-stemmed ophiocephalous pedicellariæ or tryphylta occurs, and with them are sometimes found small globifera with unusually long valves; these may be on stalks or they may have soft long necks besides stalks, and they are smaller and not so tumid as the globifera of the test itself

Upon the test there are many pedicellariæ, and the globifera are usually tumid at the base, but with a duck-mandible shaped valvular end; they are very regularly fenestrate, but the median thickening and ridge observed in *Temnopleurus* are wanting. In both genera there are usually pedicellariæ close to the pits of the sutures.

The pedicellariæ with long and short soft necks are common and are of all kinds.

The Madreporite.

The madreporite of the Temnopleurinæ is not like that of *Echinus* and *Cidaris*, for instead of the upper surface being spongy-looking and with very irregular openings, it is well defined in *Temnopleurus*, *Salmacis*, *Amblypneustes*, &c., and the water-openings are separate and large, and when decalcified they are tubular, and resemble distant cylindrical straight pipes; they have thick edges or sides lined with epithelium. The height of these cylindrical pipes is not great. The madreporite is well separated from the structure of the basal plate in which it is placed.

Valentin described and drew some fusiform, band-like muscular slips which arise at the inner edge of the periprocteal ring and pass inwards to the edge of the anus. He called them "motores ani." They are well seen in *Temnopleurus*, and staining with carmine shows very thin fibrillar muscular slips, with a considerable quantity of nerve filaments. The slips are distinct and separated.

EXPLANATION OF PLATE XI.

Fig. 1. *Microcyphus zigzag*, Agass. Side view of the plates on one side of the median ambulacral suture; knobs and sockets; dark lines indicating the sutures of the component plates of the geometrical ambulacral plates. × refers to fig. 9. Mag. Pp. 111, 113, 116.

Fig. 2. *Temnopleurus toreumaticus*, Agass. A compound ambulacral plate. *a*, adoral primary; *b*, middle demi-plate; *c*, aboral primary component plate. Mag. P. 112.

Fig. 3. A plate seen from within, during the drying of benzule, showing the great separation of the pores of the pairs. Mag. P. 113.

Fig. 4. *Salmacis bicolor*, Agass. Inner view of ambulacral plates. Same references as in fig. 3. Mag. P. 113.

Fig. 5. *Mespilia globulus*, Agass. An ambulacral plate seen from within the test under benzule. Mag. P. 113.

Fig. 6. *Microcyphus zigzag*, Agass. An ambulacral plate, sutures seen under benzule. Mag. Pp. 113, 114.

Fig. 7. Same plate from within. Mag. P. 114.

Fig. 8. Diagram of an adoral canal of a pair, oblique and reaching the peripodium. Mag. P. 114.

Fig. 9. Ambulacral plates near the apex, seen from within, under benzule. Mag. P. 114.

Fig. 10. Plates nearer the ambitus, abnormal distribution of sutures. Mag. P. 115.

Fig. 11. Plates still nearer the ambitus, abnormal, under benzule. Mag. P. 115.

Fig. 12. Plate below the ambitus, abnormal. Mag. P. 115.

Fig. 13. *Amblypneustes ovum*, Lamk., sp. Ambulacral plates with sutures under benzule: *c* is a low, broad demi-plate. P. 116.

Fig. 14. *Holopneustes purpurescens*, A. Ag. A single and double compound ambulacral plate under benzule: *a*, the adoral component plate, is a primary which is excluded at the ambulacro-interradial suture. P. 117.

Fig. 15. Inside view of plates nearer the apex. Mag. Pp. 118, 119.

Fig. 16. View corresponding to fig. 14, from within. Mag. Pp. 118, 119.

Fig. 17. *Temnopleurus toreumaticus.* A branchia decalcified and mag. 30. P. 122.

Fig. 18. Part of a finger-shaped process highly magnified. Mag. 60. P. 122.

Fig. 19. Epithelium. Mag. 120. P. 122.

Fig. 20. A small tuft of the branchia of *Salmacis* not decalcified. Mag. P. 123.

Fig. 21. Ampullæ of *Temnopleurus*, decalcified: *a*, water-canal. Mag. P. 123.

Fig. 22. Spots upon the ampullæ, with muscle-fibres leading inwards into the ampulla. Mag. 80. P. 124.

Fig. 23. End of a prong of a tridactyle pedicellaria of *Temnopleurus*. Mag. P. 129.

Fig. 24. Head of a large globifera. Mag. P. 129.

Fig. 25. A triphyltous pedicellaria, with a soft stalk placed upon a spinule. Mag. P. 129.

Fig. 26. Part of the calcareous circlet of a tentacle of *Temnopleurus*. Mag. P. 126.

Fig. 27. The psellion. Mag. P. 126.

Fig. 28. Section of a spine of *Temnopleurus*. Mag. P. 120.

The amplification in most of these drawings is small.